Stormwater Runoff Science/Engineering Newsletter
Devoted to Stormwater-Runoff Water Quality Issues

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Preface to Volume I, Number 2 Newsletter

Need for Newsletter and its Objective

The response in the technical community to the first issue of this Newsletter has been most encouraging. There is growing recognition that there needs to be much greater incorporation of mid-1990s-level science and engineering in the development of the regulatory approaches for managing the exceedances of worst-case-based water quality standards caused by chemical constituents in urban area and highway stormwater runoff. Hundreds of billions of dollars of public funds will ultimately have to be spent if achieving the current worst-case-based water quality standards continues to be the ultimate goal for the BMP ratcheting-down process for the management of chemical constituents and pathogenic indicator organisms in urban area and highway stormwater runoff. This prospect provides a strong incentive to properly evaluate the real, significant water quality/use impairments that are caused by urban-area and highway stormwater runoff-associated constituents. This is one of the primary topics addressed in this issue.

Some characterize attempts to adjust water quality standards/discharge limits for urban-area and highway stormwater runoff to more appropriately regulate chemical constituents in the runoff to protect the beneficial uses of the receiving waters without significant unnecessary public expenditures for chemical constituent control, as a "weakening" of the Clean Water Act. In their development, however, the worst-case, chemical-concentration-based water quality criteria were never intended to be mechanically applied as discharge limits for all sources to all waters. Hence, the approach that US EPA adopted in the early 1980s for implementation of the Clean Water Act requirements (in which worst-case, chemical-concentration-based water quality criteria have been adopted as national water quality criteria to serve as the basis for protecting designated beneficial uses of the Nation's waters from adverse impacts due to chemical constituents in ambient waters from any source) is not reliable. As discussed in this Newsletter, those familiar with the elements of aquatic chemistry, aquatic toxicology/biology, and water quality know that such mechanical application of worst-case criteria as state standards, can readily lead to gross over-regulation and massive waste of public and private funds in unnecessary treatment of chemical constituents in urban area and highway stormwater runoff.

As discussed in the first issue of this Newsletter, the primary objective of this professional outreach Newsletter is to provide technical information to improve the science and engineering

input for evaluating the water quality/beneficial-use impacts of chemical constituents and pathogen-indicator organisms in urban-area and highway stormwater runoff, and needed for managing the significant water quality/beneficial-use impairments cause by stormwater runoff-associated constituents. The aspect of this objective, which

is the focus of this issue, is the application/adjustment of worst-case criteria/standards to protect designated beneficial uses of waters receiving stormwater runoff in a technically valid, cost-effective manner. The editor welcomes input and perspectives from readers regarding the protection of designated beneficial uses of waters receiving urban-area and highway stormwater runoff without the incurrence of significant expenditures for unnecessary chemical constituent and pathogenic indicator organism control.

Availability of Past Newsletters

Past issues of this Newsletter are available as downloadable files from Drs. G.F. Lee and A. Jones-Lee's website, http://www.gfredlee.com

Contents of This Issue

Announcements

US EPA Water Quality Criteria and Standards Newsletter.

US EPA meeting on Water Quality Standards, Criteria and Implementation, Including Water Quality-Based Permitting will be held in Philadelphia, PA August 24-27, 1998.

US EPA public meeting, Advanced Notice of Proposed Rulemaking (ANPRM) on the Water Quality Standards Regulation on August 27 and 28, 1998

US EPA proceedings, "National Sediment Bioaccumulation Conference"

Newsletter Presentation Format

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"Pollutants" vs. "Chemical Constituents"

There are fundamental problems with how many of those working in the water quality management field use the terms "pollution," "pollutant," and "water quality" as they relate to the beneficial uses of a waterbody. This situation is especially important in the urban area and highway stormwater runoff water quality management field since the US EPA requirements governing the regulation of stormwater runoff require the control of **pollution** to the **Maximum Extent Practicable (MEP)** using **Best Management Practices (BMPs)** to ultimately achieve sufficient control of regulated constituents in stormwater runoff so they do not cause or contribute to an exceedance of water quality standards in the receiving waters for the runoff by any amount more than once every three years.

The term "water quality" is often used synonymously with chemical concentration data; authors of many so-called "water quality" reports present tables of chemical concentration data as the representation of "water quality." This approach is technically invalid and significantly misinforms the public, regulatory agencies, and others about true water quality issues and their assessment. "Water quality" can only be represented relative to the ability of the water to support the designated beneficial uses of the given waterbody. Not only does a list of chemical concentrations fail to provide such an assessment, or the sensitivity of the beneficial use(s) to alterations in any of those chemical concentrations, but also it may well not include all the information needed for determining the ability of the water to support the designated beneficial uses.

The inappropriate use of the term "water quality" that is prevalent today in the water quality management field is largely responsible for the significant over-regulation of chemical constituents for which there are water quality criteria/standards, and significantly, the under-regulation of some other constituents. The chemical characteristics of a water cannot, in general, be used to reliably characterize the true water quality - beneficial uses of a waterbody that are of concern to the public.

Until recently, the unreliable equating of "chemical concentrations" with"water quality" and other laxness in impact-assessment in much of the urban stormwater runoff water quality management field has not been of major significance to the public. Now, however, out of these approaches, the public is coming to be trapped into ultimately having to spend hundreds of billions of dollars to treat urban stormwater runoff to meet overly-protective chemical-concentration-based water quality standards. There has been a severe inattention to (indeed, disregard for) the understanding and application of aquatic chemistry and toxicology/biology in

the development of technically valid, appropriate, real water quality monitoring programs and in the reporting of results of such programs that serve as a basis for regulation.

Those responsible for conducting the US EPA National Urban Runoff Program (NURP) in the early 1980s contrived an event mean concentration (EMC) to describe the average concentrations of chemical constituents in urban area and highway stormwater runoff. This was an approach that was developed to enable the "modeling" of constituent runoff. Unfortunately, event mean concentrations are being said to be related to water quality impacts associated with urban area and highway stormwater runoff. This characterization is technically invalid when viewed from the perspective of how chemical constituents in urban area and highway stormwater runoff impact the designated beneficial uses of receiving waters for the runoff. This impact cannot be assessed through the average concentration during a runoff event. As discussed by Lee et al. (1982) and Lee and Jones-Lee (1996a), chemical constituents impact aquatic life related beneficial uses through concentrations of toxic/available forms duration of exposure relationships. Event mean concentrations cannot be used to assess the water quality impacts of urban area and highway stormwater runoff and should not be used in any water quality characterization of stormwater runoff impacts.

"Water quality" should be described relative to beneficial uses. Chemical concentration data represent a water quality characteristic which, with other information, may yield some insight into the true water quality of a waterbody. However, without additional information (such as toxicity, bioavailability, and exposure that leads to detriment to the numbers, types and characteristics of desirable forms of aquatic life) it is not possible to use chemical concentration data of the type typically presented in a so-called "water quality' report to assess aquatic life-related water quality, independent of whether the concentrations found were above or below US EPA water quality criteria.

The National Water-Quality Monitoring Council was established in May, 1997 to implement a nationwide strategy to improve water quality monitoring, assessment, and reporting activities essential to answering the questions being asked by the public on the water quality of the nation's waters. That Council developed "The Strategy for Improving Water Quality Monitoring in the United States." The Council has organized a National Monitoring Conference, Monitoring: Critical Foundations To Protect Our Waters, that will be held July 7-9, 1998 in Reno, NV. In connection with presenting a paper entitled, "Evaluation Monitoring as an Alternative to Conventional Water Quality Monitoring for Water Quality Characterization/Management" at this conference, Drs. G. Fred Lee and Anne Jones-Lee have developed a discussion of approaches that should and should not be used to characterize the water quality of a waterbody. Presented below is an outline of key issues that are presented in their paper for this conference. Additional information on these issues is available in their paper, which is available from their web site.

"Water Quality" - What It Is and What It Is Not
An Outline of Issues

"Water Quality" IS NOT a List of Chemical Concentrations

- Concentrations of Chemicals Are Water Quality Characteristics, Not "Water Quality"

- Must Consider How Chemicals Impact Organisms and Other Beneficial Uses to Assess Water Quality

By Law/Regulation & Tradition, "Water Quality" Is Defined Based on Beneficial Uses of Water

- Degraded Water Quality = Impaired Beneficial Uses
- Cannot Translate Concentrations of Chemicals to Beneficial-Use Impairment of Concern to Public

Conventional Water Quality Monitoring Focuses on Concentrations of Chemicals for Purpose of Assessing Regulatory Compliance

- Not Adequate for Assessing Water Quality
    - Example: Water Quality Issue Not Concentration of Copper in Water - Rather, Copper Toxicity to Aquatic Life
    - Water Quality Issue Not Concentration of Mercury in Water - Rather, Bioaccumulation of Mercury to Excessive Levels

Water Quality Standards & Water Quality

- Exceedance of Water Quality Criterion/Standard Not Reliable Determiner for Evaluating Real Water Quality/Use Impairment
    - US EPA Criteria Based on Worst-Case Assumptions
        - In Some Waters Concentrations of Chemicals from Some Sources Can Greatly Exceed Water Quality Criteria/Standards without Real Water Quality/Use Impairments
        - Evaluation of Water Quality Impacts of a Potentially Toxic Chemical Requires Knowledge of Relationship between Concentration of Toxic/Available Forms of Chemical & Duration of Exposure of Organisms to Toxic Conditions

Factors That Must Be Considered in Translating Concentrations of Constituent Measured in Stormwater Runoff to Potential Impacts on Aquatic Life

Stormwater Runoff

- Measured Concentration of Constituent during Runoff Event - Concentration-Time Profile
- Discharge of Runoff Waters during Runoff Event - Hydrograph
- Analytical Chemistry of Method Used for Analysis - What Chemical Species Are Measured

Receiving Waters

- Physical Factors
    - Currents, Tides - Transport/Advection
    - Mixing - Dispersion
- Biological Factors
    - Duration of Organism Exposure to Toxicant
    - Organism Movement - Locomotion; Diel Migration
    - Sensitivity to Toxicants

- Organism Assemblages - Resident Populations Relative to Habitat Characteristics

Chemical Factors

- Aquatic Chemistry
  - Kinetics & Thermodynamics of Reactions in Water of Concern
  - Additive, Synergistic, Antagonistic Reactions & Impacts
  - Toxic/Available Forms & Non-Toxic, Unavailable Forms

**Background Concentrations of Constituents of Concern

Questions That Should Be Addressed to Discern
Water Quality Impairment Due to Stormwater Runoff

- Is There Significant Toxicity in Receiving Water That Is Associated with Stormwater Runoff Events, That Could Be Adverse to Aquatic Life Populations in the Receiving Waters?
- Are There Closed Shellfish Beds, Swimming Areas, etc. That Could Be Impacted by Stormwater Runoff-Associated Pathogenic Indicator Organisms?
- Is There Excessive Growth of Algae/Aquatic Weeds That Could Be Stimulated by Aquatic Plant Nutrients (N&P) in Stormwater Runoff?
- Is There Litter and Debris Derived from Stormwater Runoff?
- Is the Receiving Water Excessively Turbid during Runoff Events?
- Is There Shoaling, or Burial of Spawning Areas, Shellfish Beds, etc. Due to Transport of Suspended Sediment in Stormwater Runoff Waters?
- Is There Accumulation of Oil and Grease in Receiving Waters That Is Either Aesthetically Displeasing and/or Adverse to Aquatic Life?
- Are Domestic Water Supplies Experiencing Treatment Problems, Excessive Costs, Due to Stormwater Runoff-Associated Constituents?

Water Quality Indicator Parameters

- Many So-Called Water Quality Indicator Parameters Are Not Reliable Measures of Real Water Quality Problems of Concern to Public
  - Must Be Able to Reliably Relate Water Quality-Related Beneficial Uses to Indicator Parameter Response
    - If Cannot Be Done, Indicator Parameter Not Reliable; Gives Unreliable Assessment of Water Quality

Consequences of Unreliable Water Quality Monitoring/Assessment

- US EPA National Water Quality Inventory Biennial Report to Congress Unreliable for Determining Amount of "Impaired" Waters in US and Causes of "Impairment"
- State & US EPA 303(d) List of Impaired Waterbodies Unreliable
  - Leads to TMDLs That Could Cause Public to Spend Unnecessarily Large Amounts of Money to Achieve Discharge Limitations with Little or No Improvement in Real Water Quality of Concern to the Public

- Conventional Water Quality Monitoring Could Cost US Public Hundreds of Billions of Dollars for "Treating" Urban Stormwater Runoff to Achieve Overly Protective Water Quality Standards
- Must Stop Wasting Public's Funds on Ill-Conceived, Inadequately Implemented, Unreliably Reported, Conventional Water Quality Monitoring Programs
    - Shift Monitoring Resources to Assessing True Water Quality/Use-Impairments of Concern to Public

Evaluation Monitoring as an Alternative to Conventional "Water Quality" Monitoring

- Focus on Evaluation of Chemical Impacts, NOT Chemical Concentrations & Loads
- Evaluate Whether Beneficial Uses of Waterbody Are Impaired
    - If Impaired, Determine Chemical(s) Responsible and the Sources of Chemicals

OP Pesticides - Aquatic Life Toxicity Example of Value of Evaluation Monitoring

- Stormwater Management Agencies Spending Several Hundred Thousand Dollars/yr on Conventional Water Quality Monitoring
    - Find Exceedances of Water Quality Standards - No Information on Water Quality Impacts
    - Did Not Detect High Levels of OP Pesticide-Related Aquatic Life Toxicity
    - Evaluation Monitoring Focuses on Toxicity & Excessive Bioaccumulation

Conclusions

- US Water Quality Monitoring Program Largely "Chemical Concentration" Monitoring Program with Little Relationship to Real Water Quality Issues
- Need National Review of Adequacy of Current Water Quality Monitoring Program to Reliably Assess the Real Water Quality of the Nation's Waters
- Need to Develop a National Water Quality Monitoring Program that Focuses on Determining Where Real Significant Water Quality Use Impairments are Occurring, the Cause of the Impairments, and the Sources of the Constituents Responsible for the Impairments
- Evaluation Monitoring Provides Basis for Developing a Reliable Water Quality Monitoring Program

Stormwater Runoff Water Quality Monitoring Under BMP Ratcheting-Down to Achieve Water Quality Standards

The US EPA's January, 1998 reaffirmation that ultimately NPDES-permitted urban area and highway stormwater runoff must be managed to not cause or contribute to violations of water quality standards in the receiving waters for the runoff with no more than one exceedance of any magnitude every three years will cost urban stormwater dischargers hundreds of millions to billions of dollars if current US EPA worst-case-based water quality criteria are mechanically used as discharge limits for urban area stormwater runoff. This requirement is to be implemented through a BMP ratcheting-down process where, when an exceedance of a standard occurs in the stormwater runoff, then the stormwater manager must report this exceedance to the Regional Board and modify its stormwater management plan to prevent future exceedances through the

implementation of additional or improved BMPs. While it is unclear how this BMP ratcheting-down process will ultimately be played out, it is clear that an in-depth, critical examination needs to be undertaken by stormwater dischargers and regulatory agencies to determine the water quality - use impairment significance of exceeding a worst-case-based standard. If it is found that the exceedance of the standard does not represent a significant beneficial use impairment, then, through the use of the US EPA's suggested approaches, adjustment of the standard/discharge limit should be implemented. The goal of the implementation is to develop a standard/discharge limit that will provide water quality protection without significant unnecessary expenditures for chemical constituent and pathogenic indicator organism control in urban area and highway stormwater runoff.

The development of the information needed to make the adjustments in this standard/discharge limit will require a significantly different type of information base than is being generated today in urban area and highway stormwater runoff water quality monitoring. The typical stormwater runoff water quality monitoring program being used today focuses on chemical constituent concentrations and loads in the runoff waters and provides little, if any, useful information on the impacts of the constituents, and especially exceedance of water quality standards on the beneficial uses of the receiving waters for the runoff. Urban stormwater runoff water quality managers, regulatory agencies and others need to begin to work together in a consensus development approach on how to best implement the BMP ratcheting-down process so as to not cause the public to waste large amounts of funds in implementing BMPs which ultimately cannot achieve "treatment/control" of the stormwater runoff potential pollutants to a sufficient degree to eliminate causing or contributing to water quality standard violations.

Development of a List of Constituents/Parameters of Concern

The urban stormwater runoff water quality manager should work with the regulatory agency and other stakeholders interested in the water quality and appropriate use of public funds for a particular waterbody and region to develop a consensus on the existing water quality use impairments for the waterbodies receiving the urban area stormwater runoff. Each NPDES-permitted stormwater runoff water quality management agency should develop a list of constituents of concern in the stormwater runoff that is causing or could cause violations of water quality standards, including narrative standards for aesthetic quality, excessive fertilization, and aquatic life toxicity. Also, consideration must be given to whether the receiving water edible aquatic life have bioaccumulated excessive concentrations of hazardous chemicals to be a threat to those who use the organism as food for humans. Basically, each of the existing beneficial uses for waterbodies receiving urban area and highway stormwater runoff should be critically examined to determine whether a use impairment of the beneficial use is occurring. If there is insufficient data on existing or potential use impairments, then additional data will need to be collected.

The previous stormwater runoff water quality monitoring results should be critically examined to determine if the concentrations of any measured parameter exceed water quality standards in the discharge waters. The California Toxics Rule (CTR) proposed water quality criteria should be used for potentially toxic constituents, for which CTR has a criterion.

Since TMDLs will have to be developed to control all constituents that cause a waterbody to attain a 303(d) listing as an impaired waterbody, urban stormwater runoff water quality managers need to critically examine the potential for their stormwater runoff to have to be "treated" to control constituents that cause a waterbody to be on a 303(d) list. The State Water Resources Control Board's final 303(d) list of impaired waterbodies recently adopted by the Board should be examined by each stormwater runoff water quality manager to see if the Regional Board for their area has listed a waterbody that receives; either directly or indirectly, stormwater runoff-derived constituents that cause or contribute to causing the waterbody to be on the 303(d) list.

In addition to considering parameters of concern in urban area and highway stormwater runoff derived from a 303(d) list, a waterbody's watershed stakeholders should determine whether there are other use impairments which are not on the 303(d) list. Further, since some Regional Boards' approach used for listing waterbodies as being impaired can readily be in significant error, such as elevated concentrations of constituents in sediments, it will be critically important to examine the validity of the Regional Boards' 303(d) listing approach. This in itself may require some special studies in order to develop the data needed to have a particular parameter removed as cause of a 303(d)-listed waterbody under conditions where it is found that the original listing was inappropriately conducted.

If the existing water quality monitoring data are not adequate to define existing or the potential for exceedances of water quality standards in the stormwater runoff as it enters the receiving waters, then the urban stormwater discharger and the regulatory agencies should work together to develop a modified stormwater runoff water quality monitoring program to fill any information/data gaps. In most cases, the composition of urban area and highway stormwater runoff is sufficiently well-known so that it is possible to determine, with a high degree of reliability for most constituents, the potential for a conventional, regulated constituent in urban stormwater runoff to contribute to a violation of a water quality standard. Therefore, there should be little need for large amounts of new, routine-type monitoring to provide the data needed to determine the constituents in urban area and highway stormwater runoff that are likely to cause exceedance of water quality standards. However, there will likely be need for toxicity testing using the US EPA's (1994) standard three species to determine whether the stormwater runoff is causing toxicity to aquatic life under the conditions of these tests. The short term acute and chronic endpoint should be used in these tests.

Evaluation of the Water Quality Significance of Exceedance of Water Quality Standards/Discharge Limits

As part of the BMP ratcheting down process, the stormwater runoff water quality manager should conduct site specific studies to determine whether the exceedance of a water quality standard at the point of a stormwater runoff entrance to a waterbody is causing a real significant use impairment of the waterbody by the public. In some cases the urban area and highway stormwater runoff, while contributing constituents of the same type as those that have caused the waterbody to have a 303 (d) listed as having a use impairment, the amount of contribution of the constituents of concern to the use impairment is insignificant compared to the amounts derived from other sources. It is certainly inappropriate to cause the urban dweller to spend large amounts of money controlling fecal coliforms in urban area stormwater runoff when the

dominant source of fecal coliforms that causes a beach closure is rural area runoff. By doing mass balance - transport fate/persistence investigations as part of the BMP ratcheting down process, it would be possible to determine whether the control of the constituents of concern in urban area and highway stormwater runoff will significantly change the beneficial use impairments that exist in a waterbody.

One of the areas of greatest concern in urban area stormwater runoff is a common finding that several heavy metals, such as copper, zinc and lead, are present in this runoff at concentrations which will cause violations of water quality standards at the point of discharge. A number of studies have shown, however, that these heavy metals are in non toxic forms and, therefore, under the current US EPA Independent Applicability Policy, the exceedance of the worst case water quality criterion/standard represents a violation of the US EPA NPDES permit discharge condition. This exceedance, however, is not a true water quality - use impairment exceedance, but is more appropriately characterized as an "administrative" exceedance associated with the use of the US EPA worst case criteria as state standards. The inappropriateness of the US EPAs independent applicability policy is widely recognized. While the policy is easy to implement, it is often technically invalid. Lee and Jones-Lee (1995) have discussed the need to abandon this policy in favor of focusing on real water quality impacts of concern to the public. The US EPA has been attempting for several years to modify the Independent Applicability Policy, to eliminate the gross over regulation that is occurring, especially when it is applied to urban stormwater runoff. Environmental activist groups, however, have thus far been able to block the current administration's efforts in this regard. The best way to get this situation changed is to conduct the studies to show that when applied to urban area and highway stormwater runoff, the public will have to spend hundreds of millions to billions of dollars removing chemical constituents (heavy metals) in urban area and highway stormwater runoff that are of concern because of the potential toxicity, but have been found, after appropriate study, to be in non toxic forms.

During the BMP ratcheting down process, while Independent Applicability Policy which requires the control of non toxic heavy metals because the concentrations exceed worst case standards, it should be possible to readily gain a variance from having to meet heavy metal water quality standards/discharge limits where it has been demonstrated that spending the funds treating water quality runoff to eliminate the exceedance of water quality standards will not result in a significant change in the beneficial uses of the receiving waters for the stormwater runoff. This is a key component of the monitoring/evaluation program that must be conducted during the BMP ratcheting down process. It will provide the technical base on which more appropriate standards - discharge limits can be adopted.

Drs. G. F. Lee and A. Jones-Lee have published extensively on the need to focus urban area stormwater runoff water quality monitoring on receiving water impacts. Their most recent paper on this topic, "Evaluation Monitoring as an Alternative to Conventional Water Quality Monitoring for Water Quality Characterization/Management," is available as a preprint of a National Monitoring Conference Proceedings from their website http://www.gfredlee.com. This paper provides background information on the need for an alternate approach water quality monitoring and the potential value of Evaluation Monitoring as an approach for obtaining the information needed during the BMP ratcheting down process. Additional details on the

implementation of the Evaluation Monitoring approach is available in papers and reports from their website.

One of the issues that needs to be addressed is whether each municipality throughout the state must conduct individual studies of the site specific impacts of their stormwater runoff associated constituents, or whether it would be possible for the municipalities, the State of California, the US EPA, and others to pool resources and conduct appropriately representative studies in a couple of areas of the state that would have applicability throughout the state. Through appropriate use of aquatic chemistry, aquatic toxicology/biology, and water quality, it would be possible to fund a few studies at selected locations to demonstrate that urban area and highway stormwater runoff can be more appropriately regulated than is occurring under the current BMP ratcheting down process. Urban area stormwater managers, regulatory agencies, environmental groups and others should work together to develop a consensus on how best to develop the data needed to determine whether the exceedance of a particular water quality standard represents a real use impairment.

Exceedance Frequency Another extremely conservative component of the US EPAs worst case based water quality criteria is a requirement that the criterion value, when implemented as a state standard, cannot be exceeded by any amount more than once every three years. This requirement is set forth in the agency's "Quality Criteria for Water - 1986," EPA 440/5-86-001. It, like many other aspects of the way in which US EPA criteria are incorporated into state standards/NPDES discharge limits, was arbitrarily developed. Clearly, the magnitude and duration of exceedance, as well as its return frequency, are important components of protecting the beneficial uses of a waterbody without significant unnecessary expenditures for chemical constituent control. This is another area that the US EPA has been addressing as part of the agency's proposed revisions of how water quality criteria are implemented into state standards and discharge limits that will be extremely important to properly regulating urban area and highway stormwater runoff associated constituents. There is no doubt that proper regulation of chemical constituents in urban area and highway stormwater runoff to protect receiving waters beneficial uses without causing the public to unnecessarily spend large amount of funds for chemical constituent control can allow a greater frequency of exceedance of water quality standards than once every three years. Further consideration should be given to the magnitude of the exceedance and its duration in assessing whether an exceedance represents a real significant water quality use impairment that should cause the public to fund its control.

Application of TMDLs to Urban Area and Highway Stormwater Runoff

The May 8, 1998 Stormwater Quality Task Force meeting included several presentations on the nature of the total maximum daily load (TMDL) development process and its application to regulating the input of constituents from all sources, including urban area and highway stormwater runoff. While mention was made in the presentations that urban area and highway stormwater runoff in the Orange County, California - Upper Newport Bay watershed was now subject to a nutrient (nitrogen and phosphorus) TMDL, there was insufficient time at the meeting to discuss some of the problems with this TMDL in regulating nutrients derived from urban areas and highways as they may impact the beneficial uses of the waterbody for which the TMDL has been developed. The nutrient TMDL issue in Orange County - Upper Newport Bay watershed is

not atypical of the problems that exist in how TMDLs have been and are continuing to be formulated which can lead to significant over-regulation and unnecessary expenditures for chemical constituent control.

As discussed in Volume 1, Number 1 of the Newsletter, the State Water Resources Control Board has recently approved over 1,400 Regional Board-requested listings of impaired waterbodies in California where TMDLs will have to be developed over the next 13 years to remove the "impaired" listing. The first step, therefore, in developing a TMDL is to critically examine whether the Regional Boards' and/or State Board's listing of a waterbody on the 303(d) list is technically valid. It is the contributor's finding that some of the Regional Boards' approaches for listing waterbodies on the 303(d) list that was recently approved by the State Board are not technically valid and, unless corrected, could result in substantial public and private expenditures for chemical constituent control from urban area and highway stormwater runoff for which little, if any, improvement in the designated beneficial uses of the 303(d) listed "impaired" waterbody will occur.

The basic problem is that those formulating TMDLs for chemical constituents are not incorporating well-established principles of aquatic chemistry, aquatic toxicology/biology and water quality in determining the allowable discharge limits that various types of sources of constituents can discharge and thereby comply with TMDL limitations. This part of the Newsletter reviews some of the issues that need to be incorporated into TMDL development to ensure that funds spent for control of constituents to comply with a TMDL, focus on controlling forms of constituents in the input waters to a waterbody that do, in fact, significantly impact the beneficial uses of the receiving waters for the inputs. The fundamental problem that exists in virtually all TMDLs developed thus far is that a mass load approach is used where the total concentrations of a constituent in runoff or discharge waters from all sources are considered equal and directly proportional to the total loads in terms of their potential impacts on the beneficial uses of the receiving waters for the discharge/runoff.

This mass load approach basically uses a 1960s level approach for incorporating science and engineering into water quality management programs. It has been known since that time that chemical constituents exist in runoff waters and aquatic systems in a variety of chemical forms, only some of which are toxic/available. Figure 1 shows the aquatic chemistry relationships that should be considered in evaluating whether a measured concentration of a constituent in stormwater runoff is in a form that is adverse to the beneficial uses of a waterbody. The mass load approach focuses on the hub of the aquatic chemistry wheel based on total concentrations of potential pollutants rather than on the rim where the actual chemical species are present that influence water quality-cause real pollution - use impairment of a waterbody.

It has been known since the 1960s that in order for aquatic life to be adversely impacted by toxic forms of chemical constituents, it is necessary that the organism be exposed to critical concentrations for a sufficient period of time to be adverse to the organism. In the case of urban area and highway stormwater runoff, it was found in the 1960s that many of the constituents of potential concern in urban area stormwater runoff are in non-toxic/non-available forms and, therefore, do not adversely impact aquatic life or other beneficial uses of the receiving waters for the stormwater runoff.

Aquatic Chemistry of Chemical Constituents

The impact of a chemical depends on the thermodynamics and kinetics of the chemical reactions that produce reaction products that occur on the rim of the aquatic chemistry wheel.

Further, as discussed by Jones-Lee and Lee (1998) in their National Water Monitoring Conference paper mentioned above, much higher concentrations of chemical constituents that are in toxic/available forms can be discharged to a waterbody, provided that the period of time over which the discharge occurs is less than the critical concentration for aquatic life duration of exposure relationship in the receiving waters for the discharge. These factors lead to the situation where US EPA worst-case-based water quality criteria, such as the "Gold Book" (1986) criteria or the soon-to-be-promulgated California Toxics Rule criteria, when mechanically implemented into receiving water standards (objectives) that must be met in urban area and highway stormwater runoff, typically lead to gross over-regulation of the regulated constituents in the runoff that are of concern because of their potential impacts to aquatic life through toxicity or to humans through bioaccumulation of hazardous chemicals in edible organism (fish and shellfish) tissue.

The US EPA in developing its water quality criteria understood the potential consequences of using their worst-case criteria as state ambient water standards. Beginning in the mid-1980s, the Agency developed extensive guidance on how the worst-case criteria can and should be adjusted for site-specific situations. This guidance is provided in the Agency's "Water Quality Standards Handbook," Second Edition (1994) (EPA 823-8-94-005). This handbook including the appendixes is about three inches thick and is available from the Office of Water resources Center, RC-4100, US EPA 401 M St. SW, Washington DC 20460, (202)260-7786. The Agency has developed a variety of approaches for modifying the worst case based water quality standards/discharge limits including: mixing zones, variances, use attainability analysis, site specific criteria/standards, etc., to protect the designated beneficial uses of receiving waters for urban area and highway stormwater runoff without unnecessary expenditures for chemical constituent control. Also the current US EPA administration is working on additional approaches through its ANPRM (see discussion presented in this Newsletter) to address the over regulation that is occurring for certain types of discharges/runoff such as urban area stormwater runoff.

Since large urban communities face expenditures of billions to tens of billion dollars for "treatment" of urban area stormwater runoff to meet current worst case based water quality criteria/standards/discharge limits, the US EPA procedures for incorporating economic factors into establishing appropriate urban area stormwater discharge limits will need to be reviewed and applied where appropriate. The Agency has issued "Interim Economic Guidance for Water Quality Standards Workbook" EPA-823-8-95-002, March, 1995 to address economic issues associated with achieving water quality standards. Further, the state of California Porter Cologne Water Quality Act includes a number of approaches for adjusting water quality objectives to reasonably protect the state's waters. Because of the high cost of meeting US EPA worst-case-based water quality criteria/standards in urban area and highway stormwater runoff, it is essential that NPDES-permitted stormwater dischargers, regulatory agencies and others work together to use the provisions that the US EPA and the state of California has developed to modify the

worst-case criteria to develop water quality standards/discharge limits that will protect designated beneficial uses of receiving waters without significant unnecessary expenditures for chemical constituent and pathogenic indicator organism control.

Available Forms of Nutrients One of the most significant deficiencies in the nutrient TMDL that was adopted for Upper Newport Bay is the failure of the regulatory agencies to incorporate nutrient control based on available forms of nutrients. During the 1960s and 1970s large amounts of work was done on eutrophication management in the US and other countries. These studies clearly demonstrated that not all forms of nutrients are available to support algal growth. Typically, nitrate, nitrite, and ammonia are readily available to algae. Only part of the organic nitrogen is available. The available part depends on the age of the organic N. Larger fractions of organic N are available from freshly developed sources. As it ages the organic N becomes more refractory and less of it is available to support algal growth through mineralization reactions.

Soluble orthophosphate is the form of phosphorus that is available to support algal growth. The regulatory agencies, in developing the nutrient TMDL for Upper Newport Bay, ignored the substantial literature that exists on algal available forms of phosphate where they based the TMDL for phosphorus on total phosphate, when most of the phosphorus added to the waterbody is associated with erosion and, therefore, is in a particulate form. Most of the particulate phosphorus derived from erosional sources is in a form that is not available to support algae and does not become available to support algal growth within the waterbody. Lee et al. (1980) developed a comprehensive review of algal available phosphate issues where they report that on the average only about 20% of the particulate phosphate is available to support algal growth. Therefore, the algal available phosphate that should be incorporated into a properly developed TMDL should be based on the soluble orthophosphate plus about 0.2 times the particulate phosphate.

Limiting Nutrients In establishing a technically valid TMDL for nutrients, it is essential to evaluate whether nitrogen and/or phosphorus is present in the waterbody at growth rate limiting concentrations during peak biomass. If the concentrations of available forms of nutrients (nitrate, nitrite, ammonia, and soluble ortho P) are surplus at peak biomass compared to the concentrations needed to support algal growth at the maximum rate, then the rate of growth of algae is not controlled by nutrients. Under these conditions the controlling factors are more likely light limitation. Soluble orthophosphate concentrations above about 0.5 µg/L P is the growth rate limiting concentration for phosphorus for planktonic algae. The corresponding value for inorganic nitrogen is about 20 µg/L N. In order to control the maximum biomass of planktonic algae is it necessary to reduce the concentrations of available forms of nutrients below one of these values. It is essential in developing a technically valid nutrient based TMDL to gain sufficient understanding of the aqueous environmental chemistry of the nutrients in the waterbody and the relationship to algal and/or other aquatic plant growth to be able to assess the potential success of establishing a TMDL for nutrients that will result in a significant improvement in the eutrophication related water quality of the waterbody of concern. Without this understanding large amounts of public funds could be spent controlling nutrient inputs from urban area and highway stormwater runoff as well as other sources that will have little or no impact on the eutrophication related beneficial uses of the waterbody for which the TMDL are being developed.

Fundamentals of Assessing Water Quality Impacts In addition to focusing on toxic/available forms of constituents in assessing the water quality impact of chemical constituents in urban area and highway stormwater runoff, another key component of any assessment of the water quality impacts of chemical constituents is an understanding of the concentration of available form - duration of exposure relationships that aquatic organisms in the receiving waters can experience associated with a runoff event. Figure 2 presents a typical relationship that exists for how chemical constituents impact aquatic life through toxicity. During short exposure times the concentrations of toxic/available forms can be increased significantly without being adverse to the organism. Basically, there is an area where the concentration of available form - duration of exposure relationship is such that there is no adverse impact over extended - chronic exposure conditions. Chronic exposure for critical life stages can be as short as a week or so for certain organisms, such as some of the zooplankton and fish larvae.

At some point in the relationship, the concentrations of toxic/available forms can be increased without being adverse to aquatic life. This is shown in Figure 2 by the sloping line. Stormwater runoff events typically lead to exposures in the order of a few hours to a day or so. While the US EPA water quality criteria for acute effects are listed as one hour averages and for chronic-four-day average concentrations, these values are somewhat arbitrarily developed for worst-case conditions. There are many chemicals in toxic/available forms where considerably longer exposures to toxic/available forms of constituents can occur without adverse impacts to aquatic life and many other beneficial uses. The US EPA is in the process of reviewing the averaging periods for acute and chronic toxicity when applied to chemical concentration-based water quality criteria/standards. This effort will ultimately likely significantly change the criterion values, especially when applied to short-term exposures, such as those typically associated with urban area and highway stormwater runoff events.

aquatic toxicity - duration of exposure diagram

Exceedance of the US EPA 1 hr average for acute and 4 day average for chronic criterion typically represents over regulation of the impacts of chemicals on aquatic life.

While, for relatively constant concentrations, such as associated with domestic wastewaters and some industrial wastewater discharges, the bulk constituents in the wastewater can be present for extended periods of time before dilution below critical levels; for stormwater runoff events, the period of time that an aquatic organism present in the receiving waters can experience a critical concentration of available form - duration of exposure is usually quite limited, and therefore much higher concentrations of constituents can be present in typical stormwater runoff without adverse impacts on the beneficial uses of aquatic life in the receiving waters for the runoff.

Another component of duration of exposure relationships that must be considered is the residence time of the potential pollutant in the waterbody. This is especially true of excessive fertilization situations where, unless there is about a week to two weeks, depending on temperature and sunlight conditions, from when the nutrients enter the waterbody until the nutrients are flushed out or diluted below critical concentrations, there is insufficient time for

planktonic algae to develop to the maximum biomass based on the nutrient load to the waterbody.

A situation has recently occurred in connection with the development of a TMDL for nutrients for Upper Newport Bay, Orange County, California where the initial proposal for the TMDL did not consider the fact that the Bay has a tidal-controlled flushing time of about 10 days. This means that soluble forms of nitrogen and phosphorus, i.e. those that are most likely the dominant source of nutrients for the excessive algae that grow in the Bay during the summer months, would be flushed through the Bay during late fall, winter and early spring and therefore do not represent nutrients that contribute to the excessive fertility problems during the critical growing season of late spring and summer. Ultimately, through the testimony of several individuals, the Regional Board and US EPA accepted that there was no need to control the nutrient inputs during the late fall, winter and early spring associated with stormwater runoff during these periods since they do not contribute to the excessive fertility problems of the Bay. However, the regulatory agencies persisted with requiring that the municipalities that have dry weather flow of nutrients to the Bay during the late fall, winter and early spring remove a certain fraction of these nutrients in accord with the TMDL requirements.

This approach can place a significant economic burden on the communities responsible for managing stormwater input to the Bay through having to control nutrient inputs during winter dry weather flow conditions. While some control can be exercised in controlling dry weather flow sources of nutrients at minimal costs to the communities, it is possible that substantial costs could have to be borne by these communities to ultimately achieve the TMDL limits that will likely have to be implemented to control the excessive growths of algae that occur each summer in Upper Newport Bay. While dry weather flow control of nutrients during late spring and summer from urban sources could potentially be justified based on its significance as a source of nutrients that contribute to the excessive fertility problem, the development of treatment works for treating dry weather flow conditions during the winter and their operations will have little or no beneficial impacts on controlling the excessive fertilization of the Bay because of the short flushing time of Bay waters. It is important to reliably assess the hydrologic, morphologic and hydraulic characteristics of the waterbody receiving the stormwater runoff in order to properly develop TMDL restrictions on discharges/runoff.

TMDLs for Potential Toxicants By far the greatest cause of 303(d) listings of waterbodies is the presence of potentially toxic constituents in the waterbody above US EPA worst-case-based water quality criteria. Many of the approximately 1,400 causes of waterbodies that are 303(d) listed as impaired waterbodies arise from the Regional Boards using an exceedance of a worst-case criteria/standard as justification for 303(d) listing. That approach is mandated by the US EPA in its guidance for developing 303(d) listed waterbodies. However, that approach can readily be in significant error, especially under conditions where the constituent that is causing the exceedance is in a non-toxic, non-available form. Lee and Jones-Lee (1997) have discussed the development of TMDLs for potentially toxic constituents, focusing on the need to properly define whether an exceedance of a water quality standard represents a real use impairment for the waterbody. This report, "Development of TMDLs from Evaluation Monitoring Program Results," is available from their web site.

The current US EPA's Independent Applicability Policy, which requires that potentially toxic constituents be controlled, even though appropriately conducted studies show that the constituents in a particular waterbody are in a non-toxic, non-available form, leads to "administrative" exceedances of water quality standards that do not represent real water quality use impairments that should be used as the basis for causing the public and others to spend money controlling constituent inputs to a waterbody under a TMDL program. Lee and Jones-Lee (1996b) have recommended that the technically valid approach for using US EPA worst case based water quality criteria as state standards involved the use of the criterion/standard values as trigger values, where, when exceeded, the water quality manager responsible for the exceedance would work with the regulatory agencies and other stakeholders in assessing the water quality significance of the exceedance in impairing the beneficial uses of the waterbody. This approach could lead to a much more technically valid, cost effective approach for managing chemical constituents in urban area and highway stormwater runoff without significant unnecessary expenditures for chemical constituent control.

Lee and Jones-Lee (1997) recommend that, as part of developing TMDLs for potentially toxic and other constituents, the regulated community and the regulatory agencies, as well as others, work together to:

- find a real water quality use impairment(s) in the receiving waters for the stormwater runoff;
- determine the cause(s) and the specific forms of the constituents responsible for the water quality use impairment;
- determine the source(s) of the constituents that are specifically responsible for the use impairment; and
- work in a stakeholder, watershed-based water quality management program with stakeholders in controlling the source(s) of the constituents in the stormwater runoff/wastewater discharges that are responsible for actual water quality use impairments to the maximum extent practicable (MEP) using appropriately developed, site-specific best management practices (BMPs).

If the exceedance of a water quality criteria/standard is found to be an "administrative" exceedance related to the overly-protective nature of most of the US EPA water quality criteria/standards when applied to urban area and highway stormwater runoff as well as many other sources of constituents, then the stakeholders for a particular waterbody should work together to make appropriate adjustments in the water quality standards for the waterbody to protect the designated beneficial uses of the waterbody without causing the public and others significant unnecessary expenditures for chemical constituent control.

Lee and Jones-Lee (1997) discuss the significant problems that can arise from the current approach of developing TMDLs for waterbodies without having sufficient understanding of the constituent load - water quality response relationship for the waterbody to formulate appropriate constituent control programs. Far too many regulatory agencies, are opting for so-called "phased" approaches where a somewhat arbitrarily developed load reduction is selected and then the system is monitored to determine if, when the load reduction is accomplished, the use impairment is controlled. This approach can readily lead to substantial waste of public and private funds in implementing TMDLs that are either not effective in controlling constituents to

the degree necessary or lead to over control of inputs of constituents beyond that needed to protect the beneficial uses of a waterbody.

Lee and Jones-Lee recommend that before a TMDL is developed, those responsible for development be required to formulate a load - response model that represents the best current information on how the waterbody for which the TMDL has been developed will respond to altered loads from each of the major sources being controlled. This modeling approach, while initially of limited reliability, can provide guidance on where the major data gaps exist and thereby focus monitoring funds on collecting the information necessary to fill these data gaps. Such a modeling approach will, if properly implemented, ultimately develop the kind of information needed to formulate more appropriate TMDLs than is typically being done today.

Announcements

The US EPA has recently published the Water Quality Criteria and Standards Newsletter. This Newsletter is used by the Agency to present information on revisions of approaches for implementation and application of water quality criteria and standards. This Newsletter is available on the Web by sending an email message to listserver@unixmail.rtpnc.epa.gov and type in the following command in the body of the message: Subscribe SASD-NEWS Firstname Lastname (example: subscribe SASD_NEWS Joan Smith). The message subject should be blank. Contact Micki Treacy at 202-260-7301 or Treacy.Micki@epamail.epa.gov for more information. This Newsletter is an important source of information on the changes in the approach that the US EPA is considering , or has adopted for regulating water quality in the US.

The US EPA will hold a meeting on Water Quality Standards, Criteria and Implementation, Including Water Quality-Based Permitting in Philadelphia, PA August 24-27, 1998. Dr. G.F. Lee has attended the past four meetings of this type, which occur every year or two, where he has found that they are an important source of information on the potential changes in water quality standards that could influence future stormwater runoff and other constituents water quality management. Some of the topics that will be discussed at the Philadelphia meeting include: introduction to the US EPA Water Criteria and Standards Plan, assessing the toxicity of mixtures, nutrient criteria, management of the sanitary quality of beaches, biological assessment and biocriteria, sediment and biological assessments, sediment quality criteria, TMDLs, whole effluent toxicity testing, bioaccumulation of hazardous chemicals, etc.

Following this meeting the US EPA has organized a separate public meeting devoted to Advanced Notice of Proposed Rulemaking (ANPRM) on the Water Quality Standards Regulation on August 27 and 28, 1998 at the same location of the Water Quality Standards meeting. Both meetings are open to anyone interested in attending. The ANPRM meeting is extremely important to urban stormwater runoff water quality mangers since its primary objective is to enable the Agency to address the significant over-regulation that occurs due to the Agency's policies adopted by past administrations. Of particular importance is the Agency's attempts to revise its Independent Applicability Policy.

The US EPA has recently published the proceedings of the "National Sediment Bioaccumulation Conference" (US EPA Office of Water (4305), EPA 823-R-98-002; February 1998) that was

held by the US EPA almost two years ago. Comments on this conference and proceedings will be presented in the next issue of the Newsletter.

Newsletter Presentation Format

The editors continue to seek a format for the Newsletter that enables it to convey useful information in a readily readable/understandable form. The editor would like to hear from the recipients of the Newsletter about whether they have received the first, and now the second, edition in a readily readable format.

At this time, the Newsletter is being developed and sent in a Corel WordPerfect 6/7/8 format through AOL. However, AOL is not necessarily compatible with all servers. Further, AOL is not consistent in how it handles text within the e-mail body, or attachments. Materials transmitted via e-mail through some e-mail servers becomes badly butchered so that it becomes extremely difficult, if not impossible, to read the material and assimilate the information.

There are over 100 individuals on the Newsletter mailing list; it is estimated that about 90% use programs that can read WordPerfect 6/7/8 with no difficulty. About 10% can read the converted Word 6/7 files. A few, however, cannot read either one. We have learned that some recipients who are using older versions of Word cannot read Word 6/7 files and therefore, our conversion to Word 6/7 is not of value to them. To address these problems, we are exploring the possibility of using the DataViz Conversions Plus 4.0 program to convert Corel WordPerfect 8 to Word 6/7 files. If any of those receiving the Word 6/7 files have difficulties with the formatting, please let us know, and we will investigate whether the DataViz Conversions Plus 4.0 program more reliably converts the formatting of our original text to Word 6/7 files. If you are having difficulties reading the Newsletter in a clean, readily readable form, please let us know, and we will work with you in finding a suitable format for transmission of the Newsletter.

In addition, because of the format problems with the Newsletter that some of its recipients are experiencing, we are exploring the possibility of using Adobe Acrobat 3.0.1 as a format for sending the Newsletter. Adobe Acrobat is a Portable Document Format (PDF) through which files can be transmitted as attachments with no loss in original formatting. The use of Adobe Acrobat requires that those sending the files purchase the program, which we are willing to do. The recipients of Adobe Acrobat files can obtain the Adobe Acrobat reader at no cost as a downloadable file from the Internet through most web browsers. There is increasing use of Adobe Acrobat being made by those who want to transmit information in a properly formatted, readily understandable form. It is our intent to submit the next version of the Newsletter in Adobe Acrobat. We would like to learn of any potential problems with this approach that may be perceived by any of the Newsletter recipients.

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Next Newsletter

The next edition of the Newsletter will focus on bioaccumulation of hazardous chemicals from water and sediments with an emphasis on appropriate interpretation of aquatic organism tissue residues to the host organism and for higher trophic level organisms, including man, who use the organisms as food. Also discussed will be the importance of focusing bioaccumulation control programs on available forms of constituents in water and sediments. A key component of this discussion will be the inappropriate approaches that the state Water Board BPTCP staff have proposed for designating and ranking toxic hotspots. Technically invalid total chemical concentration "association" approaches are proposed to designate responsible parties for the state Water Board's sediment superfund program (Aquafund). This issue will likely become very important for urban area and highway stormwater runoff water quality managers.

The Editor welcomes comments on the water quality issues discussed in this Newsletter. Send comments to G. Fred Lee at gfredlee33@gmail.com.